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ROTAMETER BACKFLOW TESTS

Report No. 91-103-K

V.P.Singh
Senior Process Development Engineer
Process Chemistry
Chemical Research Department

ABSTRACT

Tests were carried out on one of the string rotameters in the Annulus Gas System to investigate the backflow of liquid water past the ball at the bottom of the tube in the direction opposite to the normal gas flow. The rate was determined while simulating the annulus gas in the stagnant mode, i.e., compressors shut down and gas flow stopped as per the operating procedure after a high dew point rate of rise alarm. The rate was determined at which a simulated water leak from the pressure tube area backflowed through the rotameter to the upstream beetle well where detection is normally carried out with a conductivity probe. The flow rate was found to be high at low heads of water suggesting that the restriction at the ball/seat junction at the bottom of the rotameter tube does not significantly affect liquid leak detection.

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EXECUTIVE SUMMARY
ROTAMETER BACKFLOW TESTS

Report No. 91-103-K
V.P.Singh
Process Chemistry
Chemical Research Department

Beetles (liquid conductivity detection devices) have been installed in Nuclear Generating Stations upstream of the rotameters used to feed gas to the individual strings of the Annulus Gas System (AGS). In the event of a leak, dew point meters alarm and the AGS compressors are shut down to stop the gas flow; liquid water must then flow past the ball float at the bottom of the rotameter tube in a direction opposite to the gas flow during normal operation. A second alarm occurs when sufficient liquid has built up in the beetle well to allow the conduction of a small electrical current through a microammeter. Results of a limited number of tests on the rate at which the water backflows under a variety of conditions are presented in this report.

The flow rate of water was determined at different pressures of the water downstream of the rotameter. At low pressures of about 3 ft. of water, the flow rate easily exceeded the 2kg/hr reactor leak rate limit for cooling down and depressurizing the unit. The effect of different rotameter exit valve openings on the reverse flow rate was also investigated and found to be small over the normal operating range. Similarly, only a small effect was noted upon movement of the zero stop for the ball float to a position 3mm below the zero reference mark on the flow tube. It is concluded that the restriction at the ball/seat junction at the bottom of the rotameter tube does not significantly affect liquid leak detection.

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To Mr.D.W.Souther
Manager
Nuclear Engineering Dept.

ROTAMETER BACKFLOW TESTS

1.0 BACKGROUND

Beetles (liquid conductivity detection devices) have been installed in Nuclear Generating stations upstream of the rotameters used to feed gas to the individual strings of the Annulus Gas System (AGS). In the event of a leak and a high dew point alarm, the operating procedure calls for shut down of the compressors i.e., the gas flow stops; it is expected that liquid water would flow past the ball float of the rotameter in a direction opposite to the gas flow during normal recirculation with the compressors on. Results of a limited number of tests on the rate at which the water backflows under a variety of conditions are presented in this report.

2.0 EXPERIMENTAL EQUIPMENT AND PROCEDURE

The experimental equipment is shown in Figure 1. As described below, a two step procedure was used to determine the liquid backflow rate as downstream pressure increased and the exit valve position was changed.

The rotameters at Bruce NGS operate with a 12 psig upstream pressure and have an exit valve which is used to control the flow through the string of channels. For a twelve channel string which exhibits a relatively large pressure drop, only a small amount of throttling, i.e., valve closure, is required but for a four channel string, it is necessary to close the rotameter valve more. The rotameters utilize a ball float with a lower spring seat for the ball to prevent it from falling out of the tube. The flow reading is set to 65mL/sec with an integral valve at the rotameter exit and the downstream pressure is in the range 8 to 10 psig depending on the length of the individual string. The equipment shown in Figure 1(a) was used to set these conditions of gas flow and exit pressure and then the rotameter was removed from the gas system and installed as shown in Figure 1(b). This procedure closely simulated conditions in which the annulus gas system is placed in the stagnant mode (compressors off) and also when the leak essentially cuts off gas flow through the string rotameter with the compressors on.

3.0 RESULTS AND DISCUSSION

3.1 Backflow Rate Dependency on Head of Water

Figure 2 shows the flow rate of water as a function of the pressure (head) of the water downstream of the rotameter. The curve shows an approximately linear relationship between flow rate and pressure drop at low flow rates but pressure drop increases more rapidly than flow rate at high flow rate. More importantly, at low required differential pressure, the flow rate easily exceeded the 2kg/hr reactor leak rate limit for cooling down and depressurizing the unit.

3.2 Effect of Rotameter Valve Position

Figure 3 shows the effect of different rotameter exit valve opening on the reverse flow rate. During the initial set-up when the gas flow was on and for the same flow rate reading on the rotameter scale, it was necessary to open the rotameter exit valve more if a higher downstream gas pressure was required, i.e., an increase from 8 to 10 psig. Figure 3, however, shows that the reverse flow rate of liquid water was larger with the exit valve more closed. The reason for this is not fully understood. Possible causes include the occurrence of transitions from laminar to turbulent flows, and scatter in the data, for example points 13E. Also, for whatever reason, it was found nearing completion of the tests that the rotameter ball had moved down from the reference zero mark on the glass tube by about 3mm. A repeat of the flow rate data was done and these values (points 20A and 18A) are circled in Figure 3. For the 8 psig exit pressure case, on comparing points 13B and 20A, the rate had decreased by about 5mL/min . But for the 9 psig case, on comparing points 14B and 18A, the rate had increased by about 3 mL/min. Nevertheless, the flow rate easily exceeded the 2kg/h limit at very low heads. A subsequent check at Bruce NGS showed suitable ball stop positions around the zero mark on the rotameter tubes.

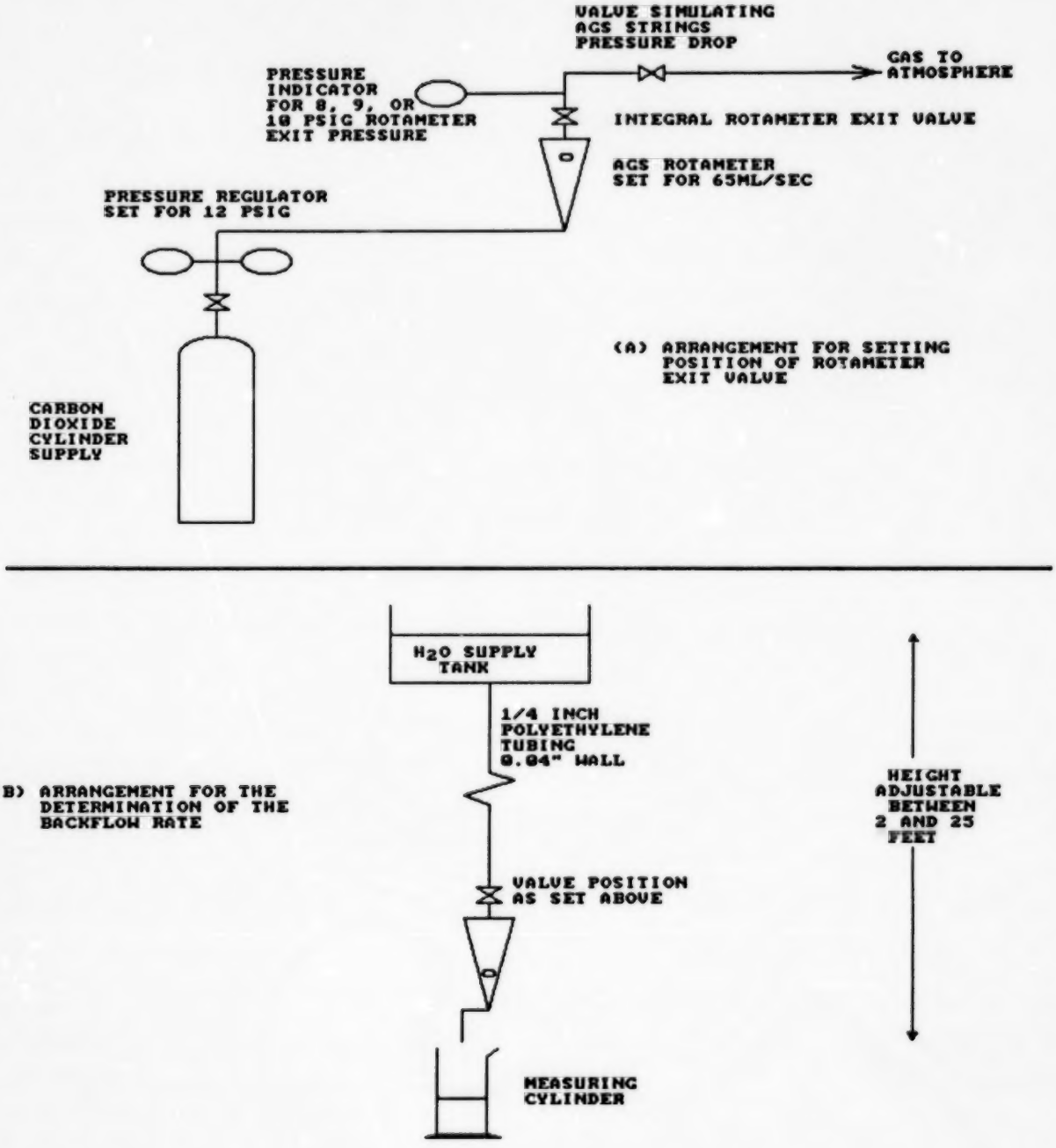

FIGURE 1. EXPERIMENTAL EQUIPMENT

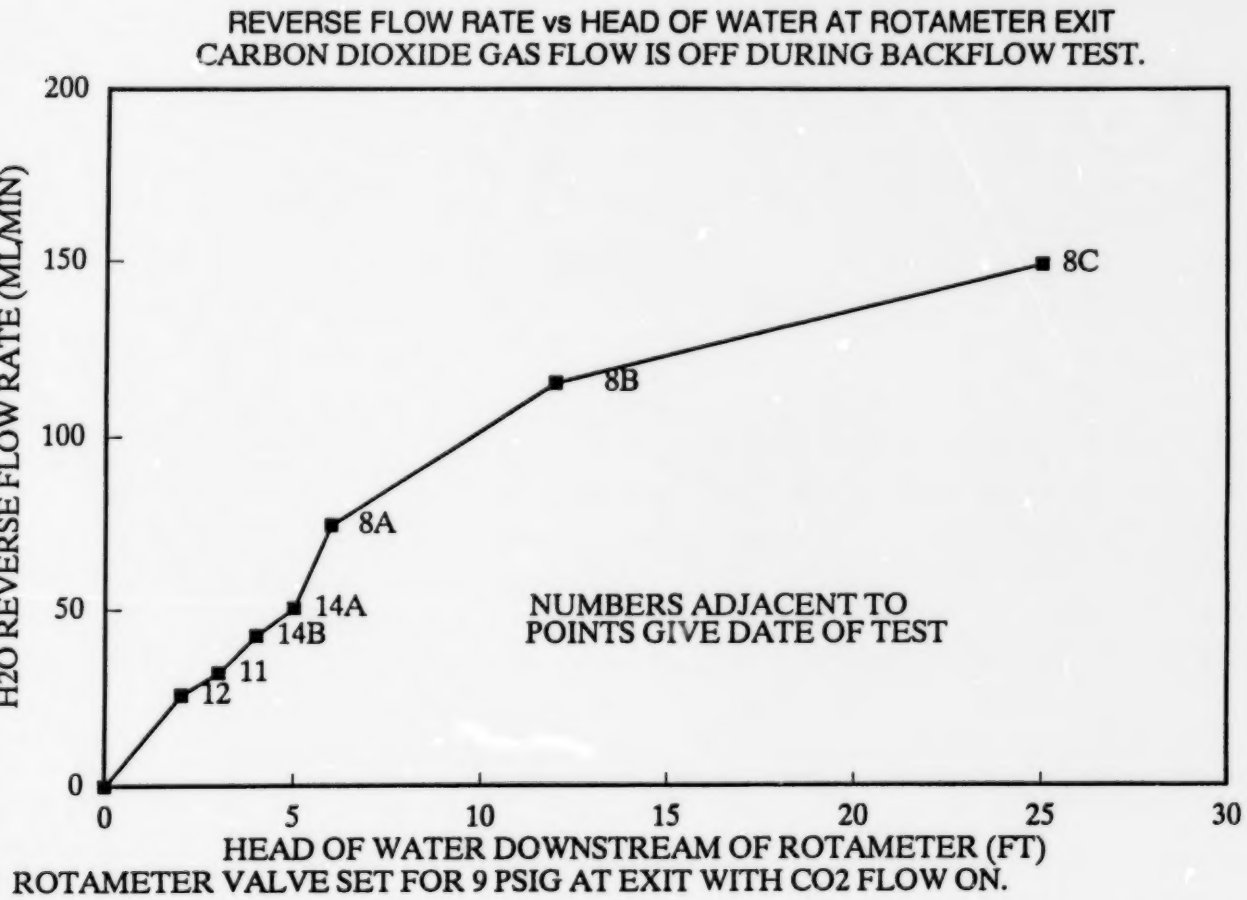

FIGURE 2. THE FLOW RATE INCREASED LINEARLY WITH PRESSURE AT LOW DOWNSTREAM PRESSURES BUT THE INCREASE WAS LESS RAPID AS PRESSURE INCREASED.

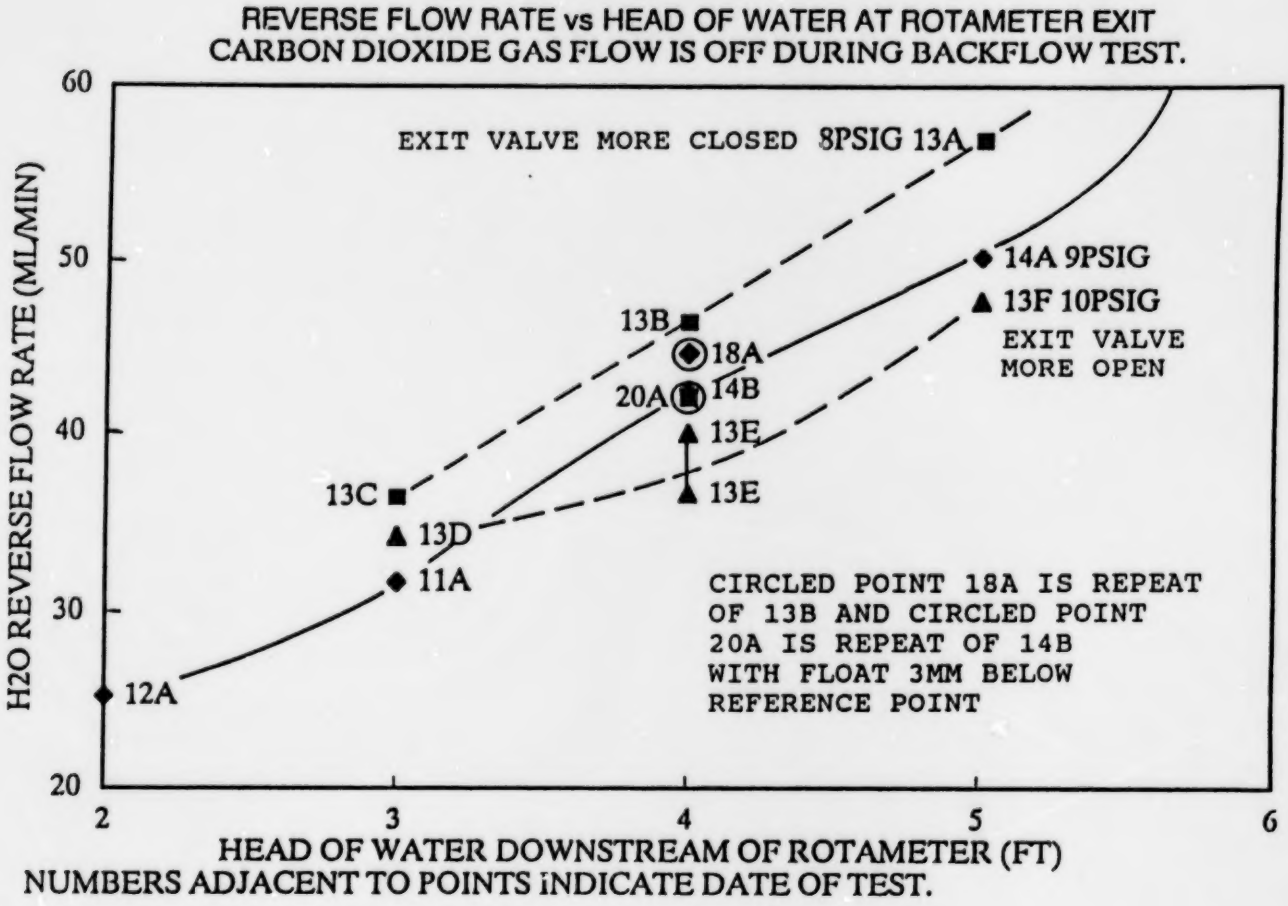

FIGURE 3. THE FLOW RATE DECREASED AS THE EXIT VALVE OPENING WAS INCREASED BUT THE FLOW RATE WAS STILL HIGH OVER THE OPERATING RANGE OF VALVE OPENINGS.

4.0 CONCLUSION

It was found that the ball at the bottom of the flow tube did not significantly impede the flow of water in the reverse direction to the normal gas flow. At low required differential pressure, the reverse flow rate easily exceeded the 2kg/hr reactor leak rate limit for cooling down and depressurizing the unit. The flow rate was affected to a small extent only by the rotameter valve position over its operating range and the position of the rotameter ball float around the zero mark on the tube.

Approved by:

D.J.R.Dodd
Manager
Chemical Research Dept.

Prepared by:

V.P.Singh
Senior Process
Development Engineer
Process Chemistry

Reviewed by:

S.H.Hawthorne
Supervising Engineer
Process Chemistry